4, Japanese Patent Application Publication H06-018779:

(54) [Title] Auto Focus Detection Device

(57) [Abstract]

[Object] To increase an amount of information of an object by making the configuration of an auto focus detection device used in an optical device such as a photographing camera and a video camera as simple as possible and also to improve focus detection accuracy of one point.

[Constitution] An auto focus detection device in which images are re-formed by an image re-formation lens 17 from object light that has passed through a taking lens 11, photoelectric conversion of the images is performed by a photoelectric conversion element 30, and an amount of focus deviation and a direction deviation are detected from the photoelectric conversion data, is equipped with the photoelectric conversion element 30 in which a plurality of line sensors 31a and 31b consisting of a sequence of photoelectric elements are provided. Then, the above line sensors 31a and 31b are brought closer and arranged in parallel.

[Scope of Claims]

[Claim 1] An auto focus detection device comprising: an optical means arranged near a focus equivalent surface of a taking lens for forming a pair of re-formation images from light that has passed through the taking lens and a photoelectric conversion means having a line sensor consisting of a sequence of light receiving elements for obtaining a distribution of quantities of light of the re-formation images, wherein in the auto focus detection device detecting a focusing state of the taking lens by computing an amount of relative deviation of the pair of re-formation images from output of the photoelectric conversion means, the photoelectric conversion means having a plurality of line sensors is provided and these line sensors are brought closer to each other and arranged in parallel.

[Claim 2] The auto focus detection device according to claim 1, wherein the photoelectric conversion means contains a line sensor in which a pitch width of a light receiving element is shifted by half a pitch.

[Detailed Description of the Invention]

[0001]

[Field of the Invention] The present invention relates to an auto focus detection device used in an optical device such as a photographing camera and a video camera.

[0002]

[Prior Art] The phase difference detection system is widely known as an auto focus detection device. FIG. 7 is a schematic diagram of principle showing an auto focus detection device of this type.

[0003] As shown in the figure, light (object light) from an object that has passed through the taking lens 11 is re-formed as two images on a photoelectric conversion element 13 by a focus detecting optical system 12 arranged near a prearranged focusing surface.

[0004] The above focus detecting optical system 12 comprises a visual field mask 14 having a rectangular mask hole, a condensing lens 15, a diaphragm mask 16 having two restrictions 16a and 16b, and an image re-formation lens 17 having two lens portions 17a and 17b. The photoelectric conversion element 13 is equipped with a line sensor consisting of a sequence of light receiving elements.

[0005] If an image of an object to be focused is formed before a prearranged focusing surface 18 (front focus), the two images re-formed on the photoelectric conversion element 13 move closer to each other, and if it is formed after the prearranged focusing surface 18 (rear focus), they move away from each other.

[0006] If an image of an object to be focused is formed on the prearranged focusing surface 18 (focused), the two images are formed on the line sensor with an interval d. The interval d is determined by the focus detecting optical system 12.

[0007] As a result, an amount of focus deviation and a direction of deviation can be determined from the interval between the images on the line sensor of the photoelectric conversion element 13.

[0008] The interval between the images on the line sensor can be determined in the following way. FIG. 8 shows a simplified diagram of a line sensor 13a held by the photoelectric

conversion element 13, and a sequence of light receiving elements on one side with respect to an optical axis 19 constitutes a base portion and that of light receiving elements on the other side constitutes a reference portion.

[0009] Moreover, an area A is determined from the sequence of light receiving elements of the base portion and areas B_1, B_2, B_3,... having as many elements as the area A are determined from the sequences of light receiving elements of the reference portion.

[0010] Then, correlation degrees between the area A and the areas B_1, B_2, B_3,... are calculated to determine with which area of image (sensor data) in the reference portion an image in the area A (sensor data) has the highest correlation.

[0011] That is, a correlation degree SX_1 between the area A and the area B_1 is determined by a formula shown below.

[Formula 1]

$$SX_1 = |a_1 - b_1| + |a_2 - b_2| + ... + |a_{10} - b_{10}| \quad (1)$$

Correlation degrees SX_2, SX_3,... between the area A and the areas B_2, B_3,... can also be determined in the same way.

[0012] If an image in the area A and that in each of the areas B_1, B_2, B_3,... completely match, as is evident from the above formula, the correlation degrees SX_1, SX_2, SX_3,... will be zero, but the two images do not usually match completely and thus the correlation degrees will not be zero.

[0013] Therefore, an area in the reference portion with the smallest value of the correlation degrees SX_1, SX_2, SX_3,... is considered a matching area.

[0014] However, since a detection resolution equal to or smaller than the light receiving element pitch of the line

sensor 13a cannot be obtained, correlation results of each area are used for interpolation to obtain a resolution equal to or less than the pitch.

[0015] A difference between an interval dx between images determined as described above and the interval d between images when focused will be an amount df of focus deviation on the line sensor surface.

$$df = dx - d \quad (2)$$

Negative df in the formula (2) means a front focus direction and positive df means a rear focus direction.

[0016] An amount of focus deviation DF on the prearranged focusing surface 18 can be determined by multiplying df with a coefficient K.

$$DF = df \times K \quad (3)$$

The coefficient K is a value determined by the focus detecting optical system 12.

[0017]

[Problems to be Solved by the Invention] In the above auto focus detection device, the range of two images 20a and 20b formed on the photoelectric conversion element 13 as two-dimensional images is determined by the mask hole of the visual field mask 14 and, in addition, the focus is detected based on object information in a very narrow range of portions of the images 20a and 20b formed on the line sensor 13a.

[0018] As a result, when a face 21 of a person is photographed near the person, as shown in FIG. 9(A), focus detection cannot be performed if a cheek is selected as a detection area because the contrast is low. Therefore, focus detection needs to be repeated by changing composition so that another facial

portion with higher contrast is contained in the detection area. This is because an auto focus detection device based on a phase detection method has a property that focus detection accuracy of an object with low contrast will be extremely low.

[0019] To solve such a problem, an auto focus detection device for obtaining more object information by providing a plurality of line sensors in a photoelectric conversion element to broaden the detection range has been disclosed by Japanese Patent Application Laid-Open No. 63-11906.

[0020] A photoelectric conversion element of the auto focus detection device disclosed by this official gazette comprises, as shown in FIG. 9(B), a line sensor 22a arranged in a horizontal position including an optical axis and two line sensors 22b and 22c arranged on both sides of the line sensor 22a in vertical positions not including the optical axis.

[0021] These three line sensors 22a to 22c are provided on a sensor substrate 23 and the visual field mask and diaphragm mask in the focus detecting optical system have mask holes provided corresponding to the line sensors 22a to 22c.

[0022] However, such an auto focus detection device has line sensors just arranged in a longitudinal or transverse direction and produces no effect from the viewpoint of improving focus detection accuracy in a narrow area.

[0023] Also, since focus detection areas are separated, there is a disadvantage that it is difficult for a photographer to see which detection area is used for focus detection, in addition to a problem of the device being larger and more complicated.

[0024] In view of the above circumstances, the present

invention of the present application has an object to develop an auto focus detection device that makes the configuration as simple as possible and can improve focus detection accuracy of one point.

[0025]

[Means for Solving the Problems] To achieve the above object, the present invention proposes, as a first invention, an auto focus detection device that comprises: an optical means arranged near a focus equivalent surface of a taking lens for forming a pair of re-formation images from light that has passed through the taking lens and a photoelectric conversion means having a line sensor consisting of a sequence of light receiving elements for obtaining a distribution of quantities of light of the re-formation images, wherein in the auto focus detection device detecting a focusing state of the taking lens by computing an amount of relative deviation of the pair of re-formation images from output of the photoelectric conversion means, the photoelectric conversion means having a plurality of line sensors is provided and these line sensors are brought closer to each other and arranged in parallel.

[0026] There is proposed, as a second invention, an auto focus detection device of the first invention, wherein the photoeletric conversion means includes a line sensor in which a pitch width of a light receiving element is shifted by half a pitch.

[0027]

[Operation] In an auto focus detection device of the first invention, even if a line sensor captures a small detection area with low contrast, another line sensor will capture a

detection area with high contrast and therefore, focus detection will never be impossible. In addition, a plurality of line sensors are brought closer and thus, even for a far-to-near mixed object, a main object will enter detection areas of two line sensors, preventing the detection areas from being lost in the background.

[0028] In an auto focus detection device of the second invention, the pitch width of light receiving element of some of the plurality of line sensors is shifted by half a pitch and therefore, suppression limits of alias can be improved without degrading photoelectric conversion sensitivity of each pixel.

[0029]

[Embodiments] Next, embodiments of the present invention will be described with reference to drawings. FIG. 1 is a schematic diagram of principle showing an auto focus detection device according to the present invention. As shown in FIG. 1, the focus detecting optical system 12 and the photoelectric conversion element 30 are arranged, like the conventional example, on the optical axis 19 of the taking lens 11.

[0030] The taking lens 11 and the focus detecting optical system 12 are configured just like the conventional example, and the focus detecting optical system 12 are arranged near a prearranged focusing surface and comprises the visual field mask 14, the condensing lens 15, the diaphragm mask 16, and the image re-formation lens 17.

[0031] As shown in FIG. 2, the photoelectric conversion element 30 has the two line sensors 31a and 31b that are brought closer and provided in parallel. And, these line

sensors 31a and 31b have a light receiving portion made of CCD elements comprising photodiodes and thus have a photoelectric conversion function to accumulate charges by receiving light.

[0032] The line sensor 31a comprises a monitor circuit 32a and a charge transfer section 33a, and the line sensor 31b comprises the monitor circuit 32a and a charge transfer section 33b.

[0033] The monitor circuits 32a and 32b control charge accumulation times of the line sensors 31a and 31b and thus are circuits for monitoring accumulated amounts of charges.

[0034] The charge transfer sections 33a and 33b are transfer registers for extracting charges accumulated in the line sensors 31a and 31b to the outside one pixel by one pixel.

[0035] The photoelectric conversion element 30 configured as described above is arranged at an optimal position for obtaining a distribution of quantities of light of a two-dimensional image formed by the focus detecting optical system 12. However, since it is only necessary that images 34a and 34b formed by the image re-formation lens 17 are projected into light receiving portions of the line sensors 31a and 31b, the shape of a mask hole 14a provided in the visual field mask 14 is determined so that light is projected by including the light receiving portions of these two line sensors 31a and 31b.

[0036] FIG. 3 is a block diagram of a circuit that controls the above photoelectric conversion element 30. Numeral 35 is an analog processing circuit, numeral 36 is a CPU, and numeral 37 is a driving circuit. The photoelectric conversion element 30, analog processing circuit 35, and driving circuit 37 are made into one chip of a focus detection IC (integrated

circuit) 38. Such a control circuit has already been applied for patent by the present applicant and disclosed as Japanese Patent Application Laid-Open No. 1-245770.

[0037] This control circuit detects a maximum voltage and a minimum voltage of charge accumulation voltages of the line sensors 31a and 31b via the monitor circuits 32a and 32b, and determines contrast of an object based on a difference between the maximum and minimum voltages.

[0038] That is, the analog processing circuit 35 equipped with a sample hold circuit, an amplifier, a selector circuit and the like samples a maximum voltage signal and a minimum voltage signal transmitted from the monitor circuits 32a and 32b before transmitting them to the CPU 36.

[0039] The CPU 36 computes a signal difference between the maximum and minimum voltage signals and transmits the signal difference to the driving circuit 37 as a charge accumulation time signal. Therefore, the driving circuit 37 causes the photoelectric conversion element 30 to stop charge accumulation.

[0040] After the contrast and charge accumulation time are monitored in this manner, the sample hold circuit and the selector circuit of the analog processing circuit 35 are switched and charges of the line sensors 31a and 31b are extracted.

[0041] That is, charges in the line sensors 31a and 31b are extracted one pixel by one pixel by the charge transfer sections 33a and 33b and an image signal is transmitted to the CPU 36 via the selector circuit of the analog processing circuit 35. At the same time, the minimum voltage signal held

by the sample hold circuit is transmitted to the CPU 36.

[0042] The CPU 36 computes a signal difference between the image signal and the minimum voltage signal and also performs a distance-measuring computation by determining, based on the signal difference, correlation degrees between the base portion and the reference portion of the line sensors 31a and 31b.

[0043] FIG. 4(A) shows a focus detection state when a person's face is photographed like the conventional example. As is evident from FIG. 4(A), the auto focus detection device in the present embodiment can perform focus detection by using an output signal of the line sensor 31a, which captures an eye portion with high contrast as a focus detection area, even if the other line sensor 31b captures a cheek with low contrast as a focus detection area.

[0044] Also, as is shown in FIG. 4(B), even for photographing of a far-to-near mixed object, the line sensors 31a and 31b are arranged after being brought closer and thus, both these line sensors 31a and 31b capture a main object 39 as a focus detection area without being lost in the background.

[0045] FIG. 5(A) shows an example in which a detection area is displayed in a camera finder 40. The actual focus detection area consists of two display areas, as shown by dotted lines in FIG. 5(B), but they are close display areas and thus may be considered as a single area and it is sufficient to display only closing lines 41 shown by solid lines. Therefore, a photographer can photograph and operate without being aware of the two display areas.

[0046] FIG. 6(A) is a partially enlarged view of a

photoelectric conversion element 42 showing another embodiment. In the photoelectric conversion element 42 in this embodiment, like the above embodiment, two line sensors 43a and 43b arranged in parallel after being brought closer have the same light receiving element pitch, but the light receiving element pitch of the line sensor 43b is shifted with respect to the line sensor 43a by half a pitch. Numeral 44 in FIG. 6(A) shows an image determined by the mask hole 14a of the visual field mask 14 and a monitor circuit and a charge transfer section are omitted in the drawing.

[0047] With the configuration described above, suppression limits of alias can be improved without degrading photoelectric conversion sensitivity of each pixel. Though high-frequency component degradation of spatial frequency is unavoidable, the resolution will be equivalent to that when one line sensor with half the light receiving element pitch is provided.

[0048] That is, capturing an image with a line sensor whose light receiving portion is made of CCD elements means discretely sampling spatial frequencies contained in an image by the interval of the light receiving element pitch and aliases will be generated for spatial frequencies exceeding the Nyquist limit.

[0049] As a means for suppressing such aliases, a method can be used by which the spatial sampling frequencies are increased to raise the Nyquist limit. In this way, the light receiving element pitch of the line sensor is made narrower to increase the number of pixels, resulting in higher resolution and improved accuracy. However, a narrower light receiving

element pitch leads to a reduced pixel area.

[0050] Since photoelectric conversion sensitivity of a line sensor whose light receiving portion consists of CCD elements is proportional to the pixel area, if the pixel area decreases as described above, the amount of signal decreases, causing degradation of S/N. The photoelectric conversion element 42 in the present embodiment solves such a problem.

[0051] The amount of focus deviation and the direction of deviation can be determined like the conventional example. That is, correlation degrees are computed by alternately synthesizing output data of the line sensors 43a and 43b.

[0052] If output data of the base portion and the reference portion of the line sensor 43a is a_1 to a_{10} and b_1 to b_{20}, and output of the base portion and the reference portion of the line sensor 43b is a'_1 to a'_{10} and b'_1 to b'_{20}, correlation degrees are computed by formulas (4) and (5).

[Formula 2]

$$SX_1 = |a_1 - b_1| + |a'_1 - b'_1| + |a_2 - b_2| + |a'_2 - b'_2| + \ldots + |a_{10} - b_{10}| + |a'_{10} - b'_{10}| \quad (4)$$

[Formula 3]

$$SX_2 = |a_1 - b'_1| + |a'_1 - b_2| + |a_2 - b'_2| + |a'_2 - b_3| + \ldots + |a_{10} - b'_{10}| + |a'_{10} - b_{11}| \quad (5)$$

Correlation degrees SX_3, SX_4, ... are also computed in the same way.

[0053] As is evident from above, the correlation degrees SX_1, SX_2, SX_3 ... can be determined by alternately synthesizing data of the two line sensors 43a and 43b to handle data like one line. While in a conventional photoelectric conversion element with one line, the correlation degree SX gives a resolution of

the pixel pitch interval, the resolution will be half a pitch according to the present embodiment.

[0054] Therefore, the number of pieces of data for computation increases, but the focus detection resolution improves two-fold and the data interpolation interval can be made narrower. As a result, it becomes possible to offer an auto focus detection device with higher focus detection accuracy.

[0055] The line sensors 43a and 43b are not necessarily limited to two and, like a photoelectric conversion element 46 shown in FIG. 6(B), three line sensors 47a, 47b, and 47c may be provided or more as long as such line sensors fall within a range of an image 45 determined by the visual field mask 14.

[0056]

[Effect of the Invention] In an auto focus detection device according to the present invention, as described above, a photoelectric conversion element including a line sensor whose light receiving element pitch width is shifted by half a pitch is provided and therefore, the resolution can be improved without degrading S/N and also the detection resolution can be improved while suppressing aliases.

[0057] Moreover, a photoelectric conversion element in which a plurality of line sensors are arranged in parallel after being brought closer is provided and therefore, even for an object for which focus is not detectable by a conventional device due to an insufficient amount of information of the object, focus can adequately be detected and also the auto focus detection device will be neither large nor complicated.

[Brief Description of the Drawings]

[FIG. 1] FIG. 1 is a schematic diagram of principle of an auto

focus detection device showing an embodiment of the present invention.

[FIG. 2] FIG. 2 is a simplified front view showing a photoelectric conversion element provided in the above auto focus detection device.

[FIG. 3] FIG. 3 is a block diagram of a circuit controlling the above photoelectric conversion element.

[FIG. 4] FIG. 4 shows a detected state of the above auto focus detection device. FIG. 4(A) shows a focus detection state when a person's face is photographed and FIG. 4(B) shows a focus detection state when a far-to-near mixed object is photographed.

[FIG. 5] FIG. 5(A) is a simplified diagram showing an example in which a focus detection area of the above auto focus detection device is caused to display within a finder. FIG. 5(B) is a diagram showing a display state by enlarging it.

[FIG. 6] FIG. 6 is a partially enlarged view of a photoelectric conversion element shown as another embodiment. FIG. 6(A) shows an example in which two line sensors are provided and FIG. 6(B) shows an example in which three line sensors are provided.

[FIG. 7] FIG. 7 is a schematic diagram of principle of an auto focus detection device shown as a conventional example.

[FIG. 8] FIG. 8 is an illustration for determining correlation degrees from output data of a base portion and a reference portion of a photoelectric conversion element.

[FIG. 9] FIG. 9(A) is a diagram showing a focus detection state by the auto focus detection device in the conventional example. FIG. 9(B) is a schematic diagram showing a

conventional example of a photoelectric conversion element having a plurality of line sensors.

[Description of Symbols]

11 Taking lens

12 Focus detecting optical system

14 Visual field mask

15 Condensing lens

16 Diaphragm mask

17 Image re-formation lens

19 Optical axis

30 Photoelectric conversion element

31a, 31b Line sensor

32a, 32b Monitor circuit

33a, 33b Charge transfer section

42 Photoelectric conversion element

43a, 43b Line sensor

46 Photoelectric conversion element

47a, 47b, 47c Line sensor

FIG. 3

35 Analog processing circuit

36 A/D converter

37 Driving circuit

FIG. 8

Area A

Base portion

Reference portion